AIAA JOURNAL
Vol. 34, No. 7, July 1996

Russian and Japanese Aerospace Literature

During 1996 the *AIAA Journal* will carry selected abstracts on leading research topics from Russian aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Stress–Strain Relationships from Russia and Magnesium Alloys from Japan.

Support for assembling and publishing the selected abstracts has been provided by the Innovative Science and Technology Directorate of the Strategic Defense Initiative Organization (SDIO), with the sponsorship and technical management of the abstract service by the Office of Naval Research (ONR) under ONR Grant N00014-93-I-1074.

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Russian Aerospace Literature
This month: *Stress–Strain Relationships*

A95-39992 An analytical method for predicting the strength of composite laminates (Analiticheskij metod prognozirovaniya prochnosti sloistykh kompozitov). R. A. AZAMATOV (AO Kamskij Avtomobil'nyj Zavod, Naberezhnye Chelny, Russia), E. S. SIBGATULLIN (Kamskij Politekhnicheskij Inst., Naberezhnye Chelny, Russia), and I. G. TEREGULOV (Kazanskij Inzhenerno-Stroitel'nyj Inst., Kazan, Russia), *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 36, No. 2, 1995, pp. 144–149. In Russian. 10 Refs. Documents available from Aeroplus Dispatch.

A simple method is proposed for predicting the strength of composites consisting of a number of similar layers. An equation for the strength surface of a layered composite is obtained based on the assumption of a uniform deformation velocity field over the thickness of the layer packet. The results are compared with the experimental data in the literature. The problem of the load-bearing capacity of a composite automotive drive shaft is solved as an example.

A95-39981 Stress–strain state of multilayer orthotropic shells of revolution of thermorheologically simple materials (Napryazhenno-deformirovannoe sostoyanie mnogoslojnykh ortotropnykh obolochek vrashcheniya iz termoreologicheski prostykh materialov). A. V. BABKOV (Kievskij Avtomobil'no-Dorozhnyj Inst., Kiev, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 8, 1994, pp. 87–94. In Russian. 4 Refs. Documents available from Aeroplus Dispatch.

A method for the numerical calculation of stress–strain components for multilayer orthotropic shells of revolution made of thermorheologically simple materials is proposed which is based on a refined version of the finite shear theory. The method employs the quadratic approximation of deformations and numerical time integration. The boundary value problem in linear viscoelasticity is solved by the discrete orthogonalization method. Calculation results based on the approach proposed here and using Schapery's method are presented for a laminated plate, a cylinder, and a cylindrical panel.

A95-39980 Invariants of the stress–strain state of thin shells (Invarianty napryazhenno-deformirovannogo sostoyaniya tonkikh obolochek). V. V. KUZNETSOV (SibNII Aviatsii, Novosibirsk, Russia), *Problemy Prochnosti* (ISSN 0556-171X), No. 8, 1994, pp. 55–61. In Russian. 10 Refs. Documents available from Aeroplus Dispatch.

A deformation theory is presented for a three-dimensional body treated as a one-parameter family of equidistant surfaces. The finite strain tensor invariants of an arbitrary surface are determined from the expansion of a squared surface area element. It is shown that, for an isotropic linearly elastic body satisfying the Kirchhoff-Love hypotheses, all the stress–strain invariants can be expressed in terms of the strain tensor invariants of a surface that is equidistant with respect to the base surface. Governing relations are derived in the context of engineering shell theory for small strains and arbitrary displacements.

A95-33478 Stress–strain state of shells with rectangular holes (Napryazhenno-deformirovannoe sostoyanie obolochek s pryamougol'nymi otverstiyami). F. F. GAYANOV and S. V. SPIRIDONOV (Inzhenerno-Stroitel'nyj Inst., St. Petersburg, Russia), *Problemy Prochnosti* (ISSN 0556-171X), No. 5, 1994, pp. 45–49. In Russian. 4 Refs. Documents available from Aeroplus Dispatch.

A study is made of the stress–strain state of shallow shells with large rectangular holes. By using special discontinuous functions, the problem is reduced to that of solving a fourth-order differential equation for a complex deflection-force function with variable coefficients in the form of delta functions, their derivatives, and columnar functions. The solution is presented in the form of basis functions consisting of series of special functions reflecting the discontinuous nature of the forces and moments and characterized by fast convergence. The results make it possible to obtain efficient computational algorithms and allow for stress concentration at the corners of the hole.

A95-33476 Validation of deformation criteria for the high-cycle fatigue of metals. I—Analysis of the known approaches (Kobosnovaniyu ispol'zovaniya deformatsionnykh kriteriev mnogotsiklovogo ustalostnogo razrusheniya metallov. I—Analiz izvestnykh podkhodov). V. V. MATVEEV (ANU, Inst. Problem Prochnosti, Kiev, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 5, 1994, pp. 11–21. In Russian. 13 Refs. Documents available from Aeroplus Dispatch.

Results obtained with different deformation criteria of fatigue fracture are examined, and the validity of these criteria is analyzed. Ways of refining the existing deformation criteria are discussed. The discussion is illustrated by experimental results obtained for steels 20Kh, 25, and 45.

A95-33475 Relationship between microstresses and macrostresses in metals (Vzaimosvyaz' mikro- i makronapryazhenij v metallakh). A. A. VAJNSHTEJN (Ural'skij Politekhnicheskij Inst., Pervouralsk, Russia), *Problemy Prochnosti* (ISSN 0556-171X), No. 4, 1994, pp. 75–83. In Russian. 9 Refs. Documents available from Aeroplus Dispatch.

Stress distribution in the microstructure of a polycrystal is described mathematically for any arbitrary stressed state. Analytical relationships are established between the microstress and macrostress statistics which make it possible to obtained additional information on stress distribution in the microstructure (based on the known values of the principal macrostresses and elasticity properties) for all the solved classical elasticity problems.

A95-28678 Geometrically nonlinear analysis of the stress–strain state of toroidal shells in pure bending (Geometricheski nelinejnyj analiz napryazhenno-deformirovannogo sostoyaniya toroidal'nykh obolochek pri chistom izgibe). S. V. LEVYAKOV, *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 36, No. 1, 1995, pp. 139–145. In Russian. 22 Refs. Documents available from Aeroplus Dispatch.

The known analytical solutions for the problem of the stress–strain state of toroidal shells in bending are applicable to shells of small initial curvature only and cannot be used for determining the stress–strain state in finite bending involving significant cross-sectional deformations. Here, a refined analytical method is used to investigate the effect of geometrical nonlinearity on the stress distribution in a toroidal shell and also to define the applicability limits of the known approximate solutions.

A95-28475 Analysis of the stress–strain state at the crack tip using a fractional-linear creep law (Analiz napryazhenno-deformirovannogo sostyaniya y vershiny treshchiny s ispol'zovaniem drobno-linejnogo zakona polzuchesti). L. V. STEPANOVA and S. A. SHESTERIKOV *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela* (ISSN 0572-

3299), No. 1, 1995, pp. 96–103. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

An exact solution is presented for the problem of the antiplane shear of a space containing a crack in the coordinate plane. The strain rates and stresses are related using expressions generalizing a fractional-linear representation. An analysis of the solution indicates that the stress fields near the crack tip correspond to the fields of a perfectly plastic body. The asymptotic behavior along the radial coordinate is determined for strain rates. It is shown that the degree of singularity depends on the angle between the radius and the crack. The boundary conditions corresponding to the exact solution of the antiplane shear problem are investigated.

A95-28473 Description of large elastic deformations (Ob opisanii bol'shikh uprugikh deformatsij). G. Z. SHARAFUTDINOV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela* (ISSN 0572-3299), No. 1, 1995, pp. 79–83. In Russian. 13 Refs. Documents available from Aeroplus Dispatch.

Some experimental data for polyurethane specimens are analyzed in a systematic manner with a view to developing an adequate approach to the study of nonlinear deformation processes. It is suggested that, in the case of finite and large elastic deformations, it could be advantageous to use the limiting case of governing relations allowing for the physical nonlinearity of the deformable material when establishing stress–strain relationships. In particular, attention is given to piecewise linear and piecewise analytical functional forms of governing relations which provide an adequate description of the uniaxial deformation of both polymers (e.g., polycarbonate, Celluloid) and metals (e.g., D16 aluminum alloy) at high temperatures in the case of sufficiently developed small deformations (up to 0.1–0.2).

A95-28472 Fundamental relations for isotropic strength-differential media–Quasilinear relations (Opredelyayushchie sootnosheniya izotropnykh raznososoprotivlyayushchikhsya sred—Kvazilinejnye sootnosheniya). N. M. MATCHENKO, L. A. TOLOKONNIKOV, and A. A. TRESHCHEV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela* (ISSN 0572-3299), No. 1, 1995, pp. 73–78. In Russian. 18 Refs. Documents available from Aeroplus Dispatch.

Stress–strain relationships are proposed for elastic bodies whose mechanical characteristics depend on the type of stressed state and which permit linear approximation of empirical dependences. It is shown that the equations presented here are capable of predicting the mechanical behavior of quasi-linear strength-differential materials over a wide range of stressed state changes. The accuracy of these predictions is shown to be significantly higher than that achieved with most of the bimodular elasticity models.

A95-25747 Normal tearing cracks in media whose deformation characteristics depend on the type of stressed state (Treshchiny normal'nogo razryva v sredakh, deformatsionnye kharakteristiki kotorykh zavisyat ot vida napryazhennogo sostoyaniya). E. V. LOMAKIN, *Moskovskij Universitet, Vestnik, Seriya 1—Matematika, Mekhanika* (ISSN 0579-9368), No. 6, 1994, pp. 54–61. In Russian. 8 Refs. Documents available from Aeroplus Dispatch.

Analysis of the stress–strain state near the crack tip in media sensitive to the stressed state type is required when solving the corresponding nonlinear problem. Here, it is shown that an asymptotic solution can be presented in the same form as in the case of conventional media. A finite solution is obtained for a particular case of functions contained in the governing equations. It is found that the dependence of the material properties on the type of stressed state has a noticeable effect on the deformation characteristics near the crack tip and on the critical stresses determining the beginning of crack growth.

A95-24389 Boundary conditions in the research of stress–strain state by optical tomography method. I. PATRIKEEV and V. SHAKHURDIN (Perm State Technical Univ., Russia), *Physics and simulation of optoelectronic devices II; Proceedings of the Meeting*, Los Angeles, CA, Jan. 1994 (A95-24352 05-74), Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 2146), 1994, pp. 440–447. 9 Refs. Documents available from Aeroplus Dispatch.

The role of boundary conditions in the correct formulation of photoelasticity problems based on the restoration of tensor fields by means of optical tomography is presented. The application of the Radon transform method makes it possible to obtain an analytical solution of the photoelasticity problem from the system of experimental and equilibrium equations. Processing of the optical experiment requires only the definition of boundary conditions in the transilluminated section. However, the definition of boundary conditions on the surface requires a preliminary regularized kernel.

A95-23764 Calculation of the warping of the bent sections of three-dimensional pipeline with multiple bends (Raschet deplanatsii izognutykh uchastkov mnogokolennykh prostranstvennykh truboprovodov). I. V. SKOMOROKHOV and N. V. SOSOV (Kazanskij Gosudarstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1994, pp. 71–76. In Russian. 3 Refs. Documents available from Aeroplus Dispatch.

Results of an experimental/theoretical study of changes in the stress–strain state of an elastically twisted pipe due to the effect of plastic bending deformations are reported. A method is proposed for calculating the warping of the bent sections of complex three-dimensional pipelines with multiple bends. Material-dependent coefficients, used in the calculation of the stress–strain state of pipelines, are presented for 12Kh18N10T, D16T, AMg2M, and AMtsM alloys.

A95-23762 Calculation of process parameters for the stretch forming of shapes with tension and radial compression (Raschet parametrov formoobrazovaniya profil'nykh detalej obtyazhkoj s rastyazheniem i radial'nym szhatiem). N. M. BODUNOV, I. M. ZAKIROV, M. I. LYSOV, and G. V. DRUZHININ (Kazanskij Gosudarstvennyj Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1994, pp. 60–65. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

An analytical method is proposed for calculating process parameters for the roller forming of shapes following bending with stretching. By using the assumption of the local effect of external forces, the roller indentation problem is reduced to a contact problem concerning the indentation of a rigid cylinder without friction into a plastic layer on a rigid foundation (bending die). The deformation of the part is described by a mathematical model which includes the principal relations of the plasticity theory for the plane deformation of an incompressible medium.

A95-23753 An analytical/experimental scheme for studying fragments of thin-walled structures (Raschetno-ehksperimental'naya skhema issledovaniya fragmentov tonkostennykh konstruktsij). A. I. GOLOVANOV, V. V. NEKHOTYAEV, A. V. PESOSHIN, and A. V. PESOSHIN (NII Matematiki i Mekhaniki, Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1994, pp. 14–18. In Russian. 2 Refs. Documents available from Aeroplus Dispatch.

A mixed scheme for investigating the stress–strain state of thin-walled structure fragments is proposed which is based on the finite element method and employs the data of several experimental methods. The requirements for the accuracy of the initial experimental data are defined. The use of the present scheme for interpreting the results of a study of the deformation of a cylindrical shell loaded by an unknown boundary force using the method of optically sensitive coatings is discussed.

A95-15606 Modeling of the defect states of structures. I (Modelirovanie defektnykh sostoyanij konstruktsij. I). O. F. BORISKIN and V. V. PERSIYANOV (Moskovskij Gosudarstvennyj Tekhnicheskij Univ., Kaluga, Russia), *Problemy Prochnosti* (ISSN 0556-171X), No. 1, 1994, pp. 100–105. In Russian. 5 Refs. Documents available from Aeroplus Dispatch.

The use of the finite element approach in conjunction with a subregion isolation technique is proposed for modeling the natural frequency spectrum and the stress–strain state of machine parts with damage. The effect of service-related damage on the natural vibration frequencies of a real compressor blade is estimated. The theoretical stress intensity factor is calculated.

A95-14914 Determination of the stress–strain state of a multilayer cylindrical pipe under dynamic loading (Opredelenie napryazhenno-deformirovannogo sostoyaniya v mnogoslojnoj tsilindricheskoj trube pri dinamicheskikh nagruzkakh). A. M. PETROV and V. P. SIZOV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela* (ISSN 0572-3299), No. 5, 1994, pp. 69–75. In Russian. 5 Refs. Documents available from Aeroplus Dispatch.

The problem of determining the stress–strain state of a multilayer pipe with transversally isotropic layers is solved by the generalized method of scalar dynamic elastic field proposed by Sizov (1988). With this method, the elastic fields are represented in terms of solutions to the wave equations, which allows the analytical solution of problems involving arbitrary local dynamic loads. In contrast to the known finite-difference approaches, numerical calculations are required only at the final stage.

A95-14492 Wave propagation in an inhomogeneous viscous medium with initial stresses (Rasprostranenie voln v neodnorodnoj vyazkouprugoj srede s nachal'nymi napryazheniyami). V. S. POLENOV and A. V. CHIGAREV *Prikladnaya Matematika i Mekhanika* (ISSN 0568-5281), Vol. 58, No. 3, 1994, pp. 181–185. In Russian. 8 Refs. Documents available from Aeroplus Dispatch.

A closed system of governing equations for the dynamic and geometrical parameters of an inhomogeneous viscoelastic medium with initial stresses is obtained in the context of three-dimensional linearized elasticity using the discontinuity theory. The geometrical characteristics of the wavefront and a ray in an infinite medium with initial stresses are determined by using the Fermat's functional principle.

A95-14484 Temperature field and thermoelastic state of a plate with a periodic system of thin elastic inclusions (Temperaturnoe pole i termouprugoe sostoyanie plastinki s periodicheskoj sistemoj tonkikh uprugikh vklyuchenij). V. K. OPANASOVICH, L. O. TISOVSKIJ, and I. I. FEDIK, *Prikladnaya Matematika i Mekhanika* (ISSN 0568-5281), Vol. 58, No. 2, 1994, pp. 139–146. In Russian. 5 Refs. Documents available from Aeroplus Dispatch.

Methods of the theory of functions of a complex variable are used to obtain a solution to the plane thermal conduction and thermoelasticity problem for a plate with a periodic system of rectilinear thin elastic inclusions of finite length. Integral expressions are obtained for the complex potentials of the temperature and stress–strain state. A system of resolving integro-differential equations is derived, and expressions are presented for the stress intensity factors at the tips of the inclusions.